BTEC Inc.

GWEC 12-1 Peaker
NOx and CO
Emissions Test Summary Report

Prepared for:

DTE Energy-GWEC Peakers

6100 West Warren Ave
Room H136
Detroit, Michigan 48120

Project No. 049AS-271586
December 5, 2017

BT Environmental Consulting, Inc.
4949 Fernlee Avenue
Royal Oak, Michigan 48073
(248) 548-8070

EXECUTIVE SUMMARY

BT Environmental Consulting, Inc. (BTEC) was retained by DTE Energy Services (DTE) to evaluate nitrogen oxides (NOx) and carbon monoxide (CO) emission rates from a single peaker unit while operating at four load conditions at the Greenwood Energy Center (GWEC) peaker facility located in Avoca, Michigan. The emissions test program was conducted on October 16, 2017.

Testing of Peaker Unit 12-1 consisted of triplicate approximate 30-minute test runs while the unit was operating at four load conditions. The emissions test program was required by 40 CFR 75, Appendix E. The results of the emission test program are summarized by Table I.

Table I
12-1 Peaker Overall Emission Summary
Test Date: October 16, 2017

Unit 12-1			
Load	**Pollutant**	**Average Emission Rate**	**Emission Limit**
85 MW	NOx	7.2 ppmv[1]	9 ppmv[1]
	CO	19.6 ppmv[1]	25 ppmv[1]
74 MW	NOx	7.2 ppmv[1]	9 ppmv[1]
	CO	19.9 ppmv[1]	25 ppmv[1]
62 MW	NOx	7.1 ppmv[1]	9 ppmv[1]
	CO	15.3 ppmv[1]	25 ppmv[1]
50 MW	NOx	7.0 ppmv[1]	9 ppmv[1]
	CO	11.7 ppmv[1]	25 ppmv[1]

1: Corrected to 15% O_2

1. Introduction

BT Environmental Consulting, Inc. (BTEC) was retained by DTE Energy Services (DTE) to evaluate nitrogen oxides (NOx) and carbon monoxide (CO) emission rates from a single peaker unit while operating at four load conditions at the Greenwood Energy Center (GWEC) peaker facility located in Avoca, Michigan. The emissions test program was conducted on October 16, 2017.

AQD has published a guidance document entitled "Format for Submittal of Source Emission Test Plans and Reports" (December 2013). The following is a summary of the emissions test program and results in the format suggested by the aforementioned document.

1.a Identification, Location, and Dates of Test

Sampling and analysis for the emission test program was conducted on October 16, 2017 at the GWEC facility located in Avoca, Michigan. The test program included evaluation of NOx and CO emissions from peaker unit 12-1.

1.b Purpose of Testing

AQD issued Renewable Operating Permit No. MI-ROP-B6145-2011a to DTE. This permit limits emissions from each turbine as summarized by Table 1.

Table 1
CO and NOx Emission Limitations
Greenwood Energy Center

Facility	Permit No.	NOx Emission Limit	CO Emission Limits
GWEC	MI-ROP-B6145-2011a	9 ppmv @ 15% O_2	25 ppmv @ 15% O_2

1.c Source Description

The DTE electric company Greenwood Energy Center located at 7000 Kilgore Road in Avoca, Michigan, employs the use of three natural gas-fired peaker turbines for the purpose of energy production. Each peaker turbine is nominally rated at 82.4 MW.

1.d Test Program Contacts

The contact for the source and test report is:

Mark Grigereit, QSTI
Senior Specialist - EMR
DTE Energy Corporate Services, L.L.C.
Detroit MI 48210

Names and affiliations for personnel who were present during the testing program are summarized by Table 2.

Table 2
Test Personnel

Name and Title	Affiliation	Telephone
Mr. Mark Grigereit Senior Specialist- EMR	DTE Energy Corporate Services, L.L.C. Detroit MI 48210	(313)-412-0305
Mr. Tim Barth Combustion Turbine Specialist	GWEC 7000 Kilgore Road Avoca, MI 48006	(313)-920-8586
Mr. Matthew Young Project Manager	BTEC 4949 Fernlee Royal Oak, MI 48073	(586) 744-9133
Mr. Shane Rabideau Enviironmental Technician	BTEC 4949 Fernlee Royal Oak, MI 48073	(248) 548-8070

2. Summary of Results

Sections 2.a through 2.d summarize the results of the emissions compliance test program.

2.a Operating Data

Process data monitored during the emissions test program included generation (MW), gas flow, inlet guide vane angle, compressor discharge temperature, compressor discharge pressure, and exhaust temperature.

2.b Applicable Permit

The applicable permit for this emissions test program is Renewable Operating Permit (ROP) No. MI-ROP-B6145-2011a.

2.c Results

The overall results of the emission test program are summarized by Table 3 (see Section 5.a). NOx emissions from peaker UNIT 12-1 were below the corresponding limit of 9 ppmv, corrected to 15% O_2. CO emissions were also below the limit of 25 ppmv, corrected to 15% O_2.

3. Source Description

Sections 3.a through 3.e provide a detailed description of the process.

3.a Process Description

The GWEC employs the use of three natural gas-fired peaker turbines for the purpose of energy production. Each peaker turbine is nominally rated at 82.4 MW.

The turbines are equipped with dry low-NOx combusters.

3.b Process Flow Diagram

Due to the simplicity of the Peaker unit, a process flow diagram is not necessary.

3.c Raw and Finished Materials

The raw material used by the process is natural gas.

3.d Process Capacity

Peaker turbine UNIT 12-1 can operate up to 82.4MW, dependent upon ambient conditions.

3.e Process Instrumentation

Process data monitored during the emissions test program included generation (MW), gas flow, inlet guide vane angle, compressor discharge temperature, compressor discharge pressure, and exhaust temperature.

4. Sampling and Analytical Procedures

Sections 4.a through 4.d provide a summary of the sampling and analytical procedures used.

4.a Sampling Train and Field Procedures

Turbine exhaust NOx content was measured using a Thermo Electron Model 42i NOx gas analyzer, the CO content was measured using a Teledyne Model 300EM CO gas analyzer, and the O_2 content was measured using a Servomex 4100 O_2/CO_2 gas analyzer. A sample

of the gas stream was drawn through an insulated stainless-steel probe with an in-line glass fiber filter to remove any particulate, a heated Teflon® sample line, and through an electronic sample conditioner to remove the moisture from the sample before it enters the analyzer. Data was recorded at 4-second intervals on a PC equipped with data acquisition software.

Sampling and analysis procedures utilized the following test methods codified at Title 40, Part 60, Appendix A of the Code of Federal Regulations (40 CFR 60, Appendix A):

- Method 3A, "*Determination of Oxygen and Carbon Dioxide Concentrations in Emissions from Stationary Sources*", was used to measure the O_2 concentration of the exhaust gas.
- Method 7E, "*Determination of Nitrogen Oxide Emissions from Stationary Sources*", was used to measure the NOx concentration of the exhaust gas.
- Method 10, "*Determination of Carbon Monoxide Emissions from Stationary Sources*", was used to measure the CO concentration of the exhaust gas.
- Method 19, "*Determination of Sulfur Dioxide Removal Efficiency and Particulate Matter, Sulfur Dioxide, and Nitrogen Dioxide Emission Rates*"
- Method 20, "*Determination of Nitrogen Oxides, Sulfur Dioxide, and Diluent Emissions form Stationary Gas Turbines*", was used for gas turbine testing methodologies.

The NOx converter efficiency was verified as specified by Method 7E.

4.b Recovery and Analytical Procedures

This test program did not include laboratory samples, consequently, sample recovery and analysis is not applicable to this test program.

4.c Sampling Ports

Figure 2 shows relevant sampling port and traverse point locations.

4.d Traverse Points

The sampling locations met the minimum criteria specified by Method 1. 12 points were sampled each test run.

5. Test Results and Discussion

Sections 5.a through 5.k provide a summary of the test results.

5.a Results Tabulation

The overall results of the emissions test program are summarized by Table 3. Detailed results for the emissions test program are summarized by Tables 4-7.

Table 3
12-1 Peaker Overall Emission Summary
Test Date: October 16, 2017

Unit 12-1			
Load	**Pollutant**	**Average Emission Rate**	**Emission Limit**
85 MW	NOx	7.2 ppmv[1]	9 ppmv[1]
	CO	19.6 ppmv[1]	25 ppmv[1]
74 MW	NOx	7.2 ppmv[1]	9 ppmv[1]
	CO	19.9 ppmv[1]	25 ppmv[1]
62 MW	NOx	7.1 ppmv[1]	9 ppmv[1]
	CO	15.3 ppmv[1]	25 ppmv[1]
50 MW	NOx	7.0 ppmv[1]	9 ppmv[1]
	CO	11.7 ppmv[1]	25 ppmv[1]

1: Corrected to 15% O_2

5.b Discussion of Results

The overall results of the emission test program are summarized by Table 3 (see Section 5.a). NOx emissions from peaker UNIT 12-1 were below the corresponding limit of 9 ppmv, corrected to 15% O_2. CO emissions were also below the limit of 25 ppmv, corrected to 15% O_2

5.c Sampling Procedure Variations

There were no sampling variations used during the emission compliance test program.

5.d Process or Control Device Upsets

No upset conditions occurred during testing.

5.e Control Device Maintenance

There was no control equipment maintenance performed during the emissions test program.

5.f Re-Test

The emissions test program was not a re-test.

5.g Audit Sample Analyses

No audit samples were collected as part of the test program.

5.h Calibration Sheets

Relevant equipment calibration documents are provided in Appendix B.

5.i Sample Calculations

Sample calculations are provided in Appendix C.

5.j Field Data Sheets

Field documents relevant to the emissions test program are presented in Appendix A

5.k Laboratory Data

There are no laboratory results for this test program. Raw CEM data is provided electronically in Appendix D.

Table 4
CTG 12-1 (85 MW) NOx and CO Emission Rates
DTE Greenwood
Greenwood Energy Center
BTEC Project No. 049AS-271586
Sampling Dates: 10/16/2017

Parameter	Run 1	Run 2	Run 3	Average
Test Run Date	10/16/2017	10/16/2017	10/16/2017	
Test Run Time	10:25-10:55	11:04-11:34	11:44-12:14	
Oxygen Concentration (%)	14.7	14.6	14.5	14.6
Oxygen Concentration (%, drift corrected as per USEPA 7E)	14.9	15.0	15.0	15.0
Outlet Oxides of Nitrogen Concentration (ppmv)	6.9	6.8	6.8	6.8
Outlet NOx Concentration (ppmv, corrected as per USEPA 7E)	7.1	7.2	7.3	7.2
Outlet NOx Concentration (ppmv, corrected to 15% O_2)	7.0	7.2	7.3	7.2
Outlet Carbon Monoxide Concentration (ppmv)	19.7	19.9	18.6	19.4
Outlet CO Concentration (ppmv, corrected as per USEPA 7E)	19.9	20.2	18.9	19.7
Outlet CO Concentration (ppmv, corrected to 15% O_2)	19.7	20.1	18.9	19.6

O_2 Correction			
Co	0.10	0.08	0.04
Cma	10.03	10.03	10.03
Cm	9.90	9.77	9.69

NOx Correction			
Co	-0.01	-0.23	-0.21
Cma	25.5	25.5	25.5
Cm	24.91	24.55	24.34

CO Correction			
Co	0.18	-0.04	-0.06
Cma	24.26	24.26	24.26
Cm	23.96	23.92	23.88

scfm = standard cubic feet per minute
dscfm = dry standard cubic feet per minute
ppmv = parts per million on a volume-to-volume basis
lb/hr = pounds per hour
MW = molecular weight (CO = 28.01, NOx = 46.01, SO_2 = 64.05, C_3H_8 = 44.10, carbon = 12.01)
24.14 = molar volume of air at standard conditions (70°F, 29.92" Hg)
35.31 = ft^3 per m^3
453600 = mg per lb

Co= Average of initial and final zero gases
Cma=Actual concentration of the calibration gas
Cm= Average of initial and final calibration gases

Equations

$Conc_{@15\%O2} = Conc * (20.9 - 15)/(20.9 - \%O_2)$

Table 5

CTG 12-1 (74 MW) NOx and CO Emission Rates
DTE Greenwood
Greenwood Energy Center
BTEC Project No. 649-AS-271586
Sampling Dates: 10/16/2017

Parameter	Run 1	Run 2	Run 3	Average
Test Run Date	10/16/2017	10/16/2017	10/16/2017	
Test Run Time	12:37-13:07	13:15-13:45	13:53-14:23	
Oxygen Concentration (%)	14.8	14.8	14.8	14.8
Oxygen Concentration (%, drift corrected as per USEPA 7E)	14.9	15.0	14.9	14.9
Outlet Oxides of Nitrogen Concentration (ppmv)	6.8	6.8	6.7	6.7
Outlet NOx Concentration (ppmv, corrected as per USEPA 7E)	7.3	7.3	7.3	7.3
Outlet NOx Concentration (ppmv, corrected to 15% O_2)	7.1	7.3	7.1	7.2
Outlet Carbon Monoxide Concentration (ppmv)	20.5	19.8	19.3	19.9
Outlet CO Concentration (ppmv, corrected as per USEPA 7E)	20.8	20.1	19.5	20.2
Outlet CO Concentration (ppmv, corrected to 15% O_2)	20.4	20.0	19.2	19.9

O_2 Correction			
Co	0.09	0.09	0.09
Cma	10.01	10.01	10.01
Cm	9.99	9.95	9.99

NOx Correction			
Co	-0.22	-0.22	-0.21
Cma	25.5	25.5	25.5
Cm	24.19	24.12	24.20

CO Correction			
Co	0.03	-0.01	-0.07
Cma	24.26	24.26	24.26
Cm	23.92	23.93	23.97

scfm = standard cubic feet per minute
dscfm = dry standard cubic feet per minute
ppmv = parts per million on a volume-to-volume basis
lb/hr = pounds per hour
MW = molecular weight (CO = 28.01, NOx = 46.01, SO_2 = 64.05, C_3H_8 = 44.10, carbon = 12.01)
24.14 = molar volume of air at standard conditions (70°F, 29.92" Hg)
35.31 = ft^3 per m^3
453600 = mg per lb

Co= Average of initial and final zero gases
Cma=Actual concentration of the calibration gas
Cm= Average of initial and final calibration gases

Equations

$Conc_{@15\%O2} = Conc * (20.9 - 15)/(20.9 - \%O_2)$

Table 6
[illegible]-1 (62 MW) NOx and CO Emission Rates
DTE Greenwood
Greenwood Energy Center
ETEC Project No. 049AS-271586
Sampling Dates: 10/16/2017

Parameter	Run 1	Run 2	Run 3	Average
Test Run Date	10/16/2017	10/16/2017	10/16/2017	
Test Run Time	14:34-15:04	15:12-15:42	15:52-16:22	
Oxygen Concentration (%)	14.9	15.0	15.0	15.0
Oxygen Concentration (%, drift corrected as per USEPA 7E)	14.9	14.9	14.9	14.9
Outlet Oxides of Nitrogen Concentration (ppmv)	6.8	6.8	6.8	6.8
Outlet NOx Concentration (ppmv, corrected as per USEPA 7E)	7.3	7.2	7.2	7.2
Outlet NOx Concentration (ppmv, corrected to 15% O_2)	7.2	7.1	7.1	7.1
Outlet Carbon Monoxide Concentration (ppmv)	15.0	16.0	15.2	15.4
Outlet CO Concentration (ppmv, corrected as per USEPA 7E)	15.1	16.2	15.5	15.6
Outlet CO Concentration (ppmv, corrected to 15% O_2)	14.9	15.9	15.2	15.3

O_2 Correction			
Co	0.11	0.14	0.13
Cma	10.01	10.01	10.01
Cm	10.08	10.13	10.12

NOx Correction			
Co	-0.23	-0.24	-0.22
Cma	25.5	25.5	25.5
Cm	24.47	24.68	24.63

CO Correction			
Co	-0.07	-0.09	-0.12
Cma	24.26	24.26	24.26
Cm	24.00	23.96	23.92

scfm = standard cubic feet per minute
dscfm = dry standard cubic feet per minute
ppmv = parts per million on a volume-to-volume basis
lb/hr = pounds per hour
MW = molecular weight (CO = 28.01, NOx = 46.01, SO_2 = 64.05, C_3H_8 = 44.10, carbon = 12.01)
24.14 = molar volume of air at standard conditions (70°F, 29.92" Hg)
35.31 = ft^3 per m^3
453600 = mg per lb

Co= Average of initial and final zero gases
Cma=Actual concentration of the calibration gas
Cm= Average of initial and final calibration gases

Equations

$Conc_{@15\%O2}$ = Conc * (20.9 -15)/(20.9 - $\%O_2$)

Table 7
CTG 12-1 (50 MW) NOx and CO Emission Rates
DTE Greenwood
Greenwood Energy Center
BTEC Project No. 649AS-[illegible]
Sampling Dates: 10/16/2017

Parameter	Run 1	Run 2	Run 3	Average
Test Run Date	10/16/2017	10/16/2017	10/16/2017	
Test Run Time	16:31-17:01	17:10-17:40	17:48-18:18	
Oxygen Concentration (%)	14.9	14.8	14.8	14.9
Oxygen Concentration (%, drift corrected as per USEPA 7E)	14.9	14.9	14.9	14.9
Outlet Oxides of Nitrogen Concentration (ppmv)	6.7	6.7	6.6	6.6
Outlet NOx Concentration (ppmv, corrected as per USEPA 7E)	7.1	7.2	7.1	7.1
Outlet NOx Concentration (ppmv, corrected to 15% O_2)	**7.0**	**7.0**	**6.9**	7.0
Outlet Carbon Monoxide Concentration (ppmv)	11.4	11.7	12.0	11.7
Outlet CO Concentration (ppmv, corrected as per USEPA 7E)	11.6	12.0	12.3	12.0
Outlet CO Concentration (ppmv, corrected to 15% O_2)	**11.4**	**11.7**	**12.0**	11.7

O_2 Correction			
Co	0.12	0.12	0.12
Cma	10.01	10.01	10.01
Cm	10.08	10.04	10.02

NOx Correction			
Co	-0.22	-0.22	-0.21
Cma	25.5	25.5	25.5
Cm	24.38	24.29	24.26

CO Correction			
Co	-0.10	-0.22	-0.12
Cma	24.26	24.26	24.26
Cm	23.91	23.90	23.83

scfm = standard cubic feet per minute
dscfm = dry standard cubic feet per minute
ppmv = parts per million on a volume-to-volume basis
lb/hr = pounds per hour
MW = molecular weight (CO = 28.01, NOx = 46.01, SO_2 = 64.05, C_3H_8 = 44.10, carbon = 12.01)
24.14 = molar volume of air at standard conditions (70°F, 29.92" Hg)
35.31 = ft^3 per m^3
453600 = mg per lb

Co= Average of initial and final zero gases
Cma=Actual concentration of the calibration gas
Cm= Average of initial and final calibration gases

Equations

$Conc_{@15\%O2}$ = Conc * (20.9 -15)/(20.9 - $\%O_2$)

BTEC Inc.

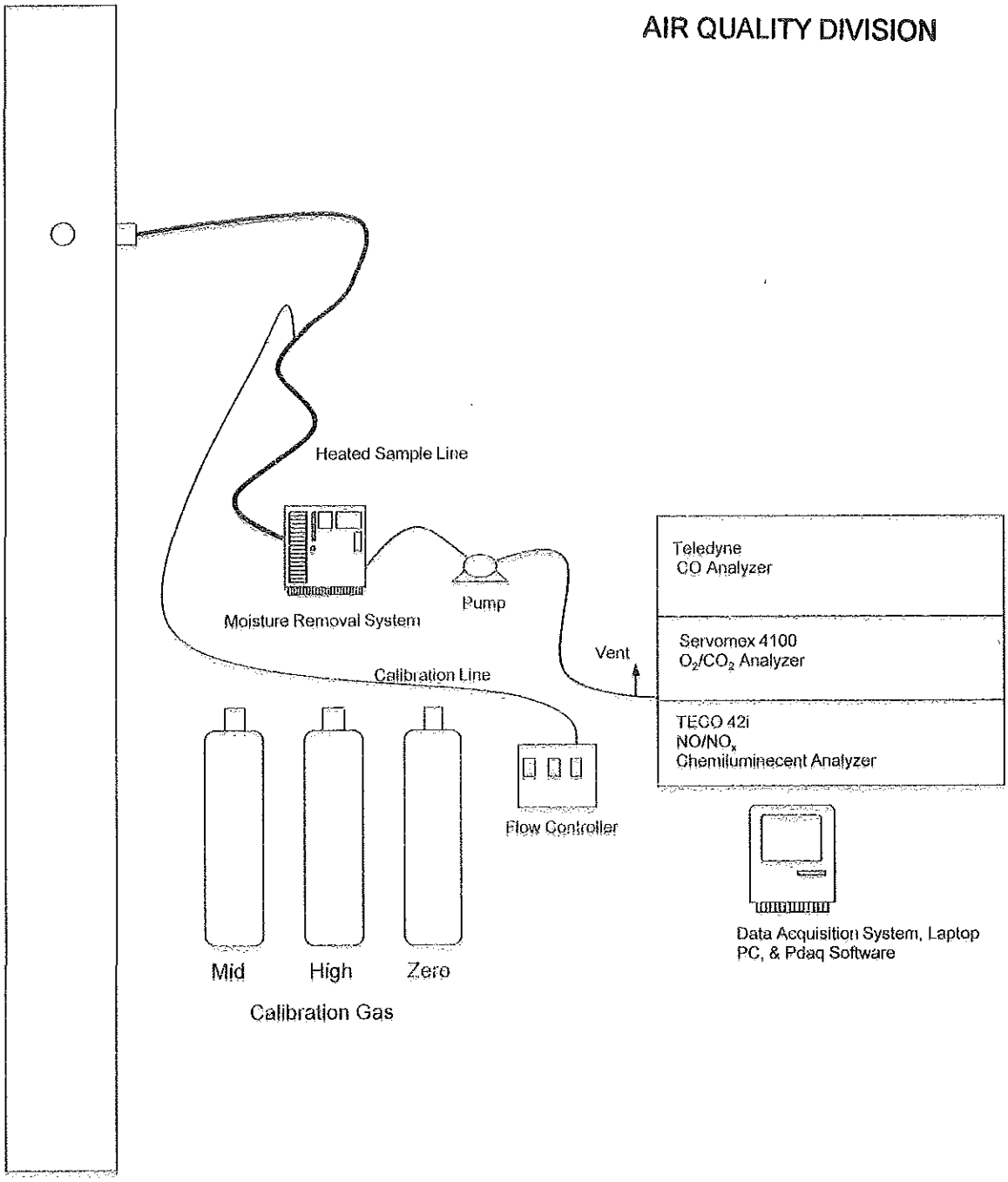

Figure No. 1

Site: USEPA Method 3A, 7E, and 10 GWEC Avoca, Michigan	Sampling Date: October 16, 2017	BT Environmental Consulting Inc. 4949 Fernlee Avenue Royal Oak, MI 48073

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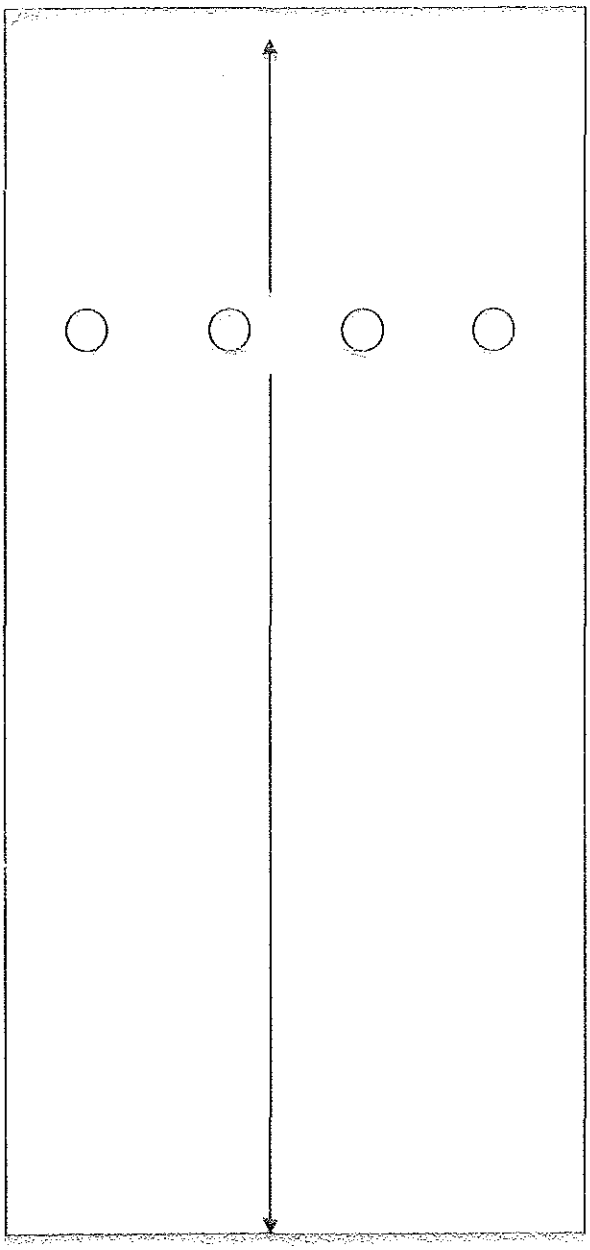
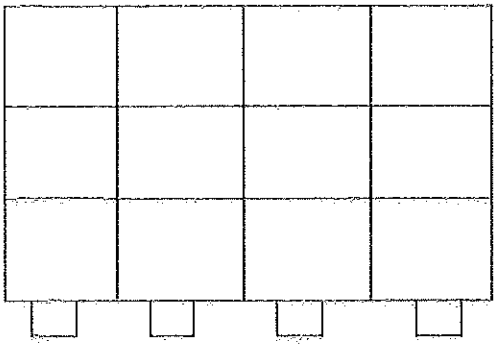
Stack Dimensions:

Depth: 108 inches

Width: 228 inches





Not to Scale

Points	Distance "
1	18.0
2	54.0
3	90.0

Figure No. 2

Site:
12-1 Peaker
GWEC
Avoca, Michigan

Sampling Date:
October 16, 2017

BT Environmental Consulting, Inc.
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